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AUTHORS: Ivanov, A. P., Berkovskiy, B. M., Katsev, I. L.

TITLE: Reflection and transmission of a plane-parallel layer in the scope of non-linear optics

PERIODICAL: Inzhenerno-fizicheskiy zhurnal, v. 5, no. 10, 1962, 58 - 64

TEXT: The subject of investigation is a plate of thickness l and of small luminance characterized by the absorption coefficient k_0 and the reflection coefficient on the face r . A luminous flux S_0 is incident perpendicularly. Owing to multiple reflection there exist internally two kinds of flux at any point x : S_1 moving parallel to the incident flux, and S_2 moving in the opposite direction. These are described by the differential equations $dS_1 = -kS_1 dx$, $dS_2 = kS_2 dx$ (1) with the boundary conditions $S_1(x=0) = S_0(1-r) + rS_2(x=0)$, $S_2(x=l) = rS_1(x=l)$ (2). The absorption coefficient can be expressed by $k = k_0 / (1 + \alpha(S_1 + S_2))$, where

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the parameters of non-linearity α and k_0 are assumed to be constant with respect to depth. The system (1) is solved by

$$\ln C_2 \alpha S_1 + \alpha S_1 - \frac{C_1}{\alpha S_1} = -k_0 x, \quad \ln \frac{\alpha S_2}{C_1 C_2} + \alpha S_2 - \frac{C_1}{\alpha S_2} = k_0 x. \quad (4)$$

and the relation $S_1 S_2 = C_1 / \alpha^2$ can be derived additionally from (1), stating that the product of two oppositely directed fluxes is constant at any depth. Hence the reflection coefficient R is obtained by

$$R = \frac{(1-r)C_1}{\alpha S_0 A} + r. \quad (8)$$

and the transmission factor T by

$$T = \frac{1-r}{\alpha S_0} \sqrt{\frac{C_1}{r}}. \quad (9)$$

On the basis of these formulas the light field was studied inside and outside the medium. For the region where k_0 is positive R and T are calculated by

$$R = r + \frac{(1-r)^2 r \exp(-2k_0 l)}{1 - r^2 \exp(-2k_0 l)}, \quad T = \frac{(1-r)^2 \exp(-k_0 l)}{1 - r^2 \exp(-2k_0 l)}. \quad (10)$$

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for the condition $\alpha S_0 \ll 1$, and by

$$R = \frac{2r}{1+r} - \frac{2r}{\alpha S_0 (1+r)^2} k_0 l, \quad (11)$$

$$T = \frac{1-r}{1+r} - \frac{1}{\alpha S_0} k_0 l$$

for the condition $\alpha S_0 \gg 1$. For the region of negative values of k_0 ,

$$R = \frac{2\alpha S_0 k_0 l r - 2r(1-r)(\alpha S_0)^2 - r(k_0 l)^2}{\alpha S_0 [2k_0 l r - \alpha S_0 (1-r^2)]} \quad (14)$$

$$T = \frac{(1-r^2)k_0 l \alpha S_0 - (1-r)^2(\alpha S_0)^2 - r(k_0 l)^2}{\alpha S_0 [2k_0 l r - \alpha S_0 (1-r^2)]}$$

holds for high luminances. At high values of r the energy density distribution in the plate is virtually constant. At small values, this distribution has a minimum in the interior of the plate which vanishes if $r \rightarrow 1$. There are 4 figures.

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